

# WATER QUALITY SITE ASSESSMENT FOR SOILS AND GROUND WATER

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This paper will describe how a site-wide water quality site assessment should be conducted to evaluate the impact of soil contaminants on ground water quality.

The first step is to establish background conditions for both soils and ground water. The purpose of establishing background concentrations is to accurately assess whether detection of a constituent represents man-made contamination or a naturally occurring concentration. Assessment of background may also be necessary in determining cleanup levels that are protective of the quality of waters of the State. If a constituent is detected at a statistically significant concentration above background, then it is considered a constituent of concern for water quality and remediation may be necessary to protect beneficial uses and to restore and protect native water quality, as feasible. A site-wide assessment of background levels should be conducted in accordance with the regulations of Article 5 of Chapter 15, Division 3, Title 23 of the California Code of Regulations (CCR).

The stratigraphy of the unsaturated and saturated zones beneath the facility should be well defined by the discharger. Hydrogeologic zones must be clearly defined. This is important in order to delineate contaminant transport pathways and water resources that have or may be affected by site contaminants.

Background levels need to be established for all distinct lithologies above and below the water table. In urban and industrial areas it is often difficult and sometimes impossible to establish true background concentrations for shallow soils above the water table, due to extensive past waste management activities. Off-site, undisturbed areas may need to be sampled. It will be necessary to establish site-wide background levels for soils based on extractable (soluble) concentrations, determined by a variation of the Title 22 CCR Waste Extraction Test (WET). By using extractable concentrations, the assessment determines what quantities of unsaturated zone contaminants and constituents are mobile and present a threat to water quality.

First, the process for establishing background concentrations in ground water and selecting appropriate water quality limits will be discussed. Second, the process for establishing extractable background concentrations in soils will be described. Finally, this paper will describe how to convert soil extract data into a form for comparison with background ground water concentrations and water quality limits.

## **Site-wide Background Assessment of Ground Water Zones**

1. Select a minimum of four ground water sampling sites that, based on available information, are out of the influence of past waste management activities. These should be upgradient of existing and potential site contaminants. Off-site sampling may be necessary if unimpacted areas cannot be found on-site.

2. Collect filtered ground water samples, and ensure that no sample aeration takes place. At each sampling location, collect a sample from all hydrogeologic zones identified beneath the water table. Analyze each sample for the following dissolved constituents and parameters:

Title 22 Metals      As, Ag, Ba, Be, Cu, Cd, Co, Cr (Total), Cr<sup>+6</sup>, Hg, Mo, Ni, Pb, Se, Ti, V, and Zn;

General Minerals      Ca, Mg, Na, K, Fe, Al, Mn, SO<sub>4</sub>, Cl, NO<sub>3</sub>, and alkalinity; and

General Parameters      EC, pH, and TDS.

*[Other constituents may need to be added, based on knowledge of past site activities.]*

3. Calculate the mean and the standard deviation of the mean dissolved concentration for each constituent and parameter in each hydrogeologic zone to establish site-wide background concentrations for the different ground water zones.

### **Constituent Assessment in Assessment Areas for Ground Water**

1. For each assessment area, determine the dissolved ground water concentrations for all general minerals and parameters, and for those Title 22 Metals that are suspected constituents of concern, based on past industrial and waste management activities for that area. *[Other constituents may need to be added, based on knowledge of past site activities.]*
2. Statistically compare each constituent's dissolved concentration from each assessment area for each hydrogeologic zone with each constituent's background ground water concentration for that ground water zone.
  - a. If an assessment area ground water concentration for a constituent in a specific ground water zone is less than the background ground water concentration for that constituent in the same ground water zone, then the constituent is not a constituent of concern for water quality. No further action is required for that constituent in that ground water zone, provided that the concentration does not present a risk to human health.
  - b. In an assessment area, if the concentration of a constituent in a ground water zone is greater than the background ground water concentration for that constituent in the same ground water zone, then the constituent is a constituent of concern for water quality. This means that ground water degradation has occurred and ground water remediation may be necessary. In addition, if the same contaminant is present in overlying soils, contaminant breakthrough has occurred and no attenuative capacity is available for that constituent within overlying soils at that site.

### Determination of Water Quality Limits

To determine whether past waste management activities have degraded or have the potential to degrade water quality, applicable water quality limits need to be determined for the contaminants involved. Water quality limits are numerical contaminant concentrations, above which contaminants are considered to have adversely impacted beneficial uses (to have limited certain uses) of waters of the state. Water quality limits are used to implement the numerical and narrative water quality objectives contained in the state and regional *Water Quality Control Plans*.

To select water quality limits, determine the following:

- ❑ beneficial uses of the water body being investigated;
- ❑ applicable water quality objectives to protect those beneficial uses;
- ❑ numerical water quality limits that will implement all applicable water quality objectives (i.e. drinking water standards, water quality criteria for agriculture, health advisories, Proposition 65 No-Significant-Risk Levels, etc.); and finally,
- ❑ choose the most limiting value to be the water quality limit for each particular constituent, because it is protective of all beneficial uses.

During the site assessment phase of a site investigation, detected constituent concentrations are compared to numerical water quality limits to determine if beneficial uses have been impacted. During the cleanup level determination phase, the background concentration is selected as the initial cleanup level, based on State Board Resolution Nos. 92-49 (*Policies and Procedures for Investigation and Cleanup and Abatement of Discharges under Water Code Section 13304*) and 68-16 (*Antidegradation Policy*). If the discharger demonstrates that it is technologically and/or economically infeasible to achieve background concentrations, then some achievable cleanup level between background and the water quality limit can be negotiated. However, any cleanup level greater than background based on feasibility must still comply with all applicable statutes and regulations, and must not cause risk to human health and the environment, including beneficial uses of water.

### Site-wide Background Assessment of Soils

1. Select a minimum of four soil sampling sites that, based on available information, appear to be out of the influence of past waste management activities. Off-site sampling may be necessary if unimpacted areas cannot be found on-site.
2. Collect a soil sample at each location from each lithology type present above the water table. Each soil sample must be large enough to perform the Waste Extraction Test (WET) procedure with deionized water, <sup>1</sup> and to analyze the extract for all of the following:

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<sup>1</sup> The standard citrate buffer should be used if the soils are significantly acidic or could become acidic.

Title 22 Metals	As, Ag, Ba, Be, Cu, Cd, Co, Cr (Total), Cr <sup>+6</sup> , Hg, Mo, Ni, Pb, Se, Ti, V, and Zn;
General Minerals	Ca, Mg, Na, K, Fe, Al, Mn, SO <sub>4</sub> , Cl, NO <sub>3</sub> , and alkalinity; and
General Parameters	EC, pH, and TDS.

*[Other constituents may need to be added, based on knowledge of past site activities.]*

3. Calculate the mean soil extract concentration (in ug/l of WET extract) for each constituent in each lithologic unit. Also, determine the standard deviation for each mean calculation. This establishes the site-wide background concentrations of extractable levels in soil extracts for each constituent in each distinct lithologic unit within the unsaturated zone.

### **Constituent Assessment in Assessment Sites for Soils**

1. For each assessment site, determine the soil extract concentrations (in ug/l of WET extract) for all general minerals and parameters, and for those Title 22 Metals that are suspected constituents of concern, based on past industrial and disposal activities for that site. *[Other constituents may need to be added, based on knowledge of past site activities.]* Sufficient samples shall be collected and analyzed to provide data representative of the range of concentrations present.
2. Statistically compare the soil extract concentrations from each assessment site for each lithology with the corresponding soil extract concentrations from the site-wide background assessment for each lithology:
  - a. If an assessment site soil extract concentration is less than or equal to the site-wide background soil extract concentration for a constituent in a specific lithology, then ground water quality is not threatened by that constituent, and no further action is required for that constituent in that lithology.
  - b. If an assessment site soil extract concentration is greater than the site-wide background soil extract concentration for a constituent, then that constituent is potentially a threat to ground water, and the assessment site soil extract concentration must be compared with the site-wide background concentrations for ground water and the applicable water quality limits.
3. In order to compare an assessment site soil extract concentration to background ground water quality and numerical water quality limits, the soil extract concentration must be converted into assessment site soil leachate concentrations, because the WET procedure includes a 10-fold dilution of the soil sample (see Attachment A, a discussion of "Environmental Leachate vs. WET Extracts").
  - a. Site Soil Leachate Concentration = 10 x (Site WET Extract Concentration)

- b. When an assessment site soil leachate concentration is less than or equal to the background ground water concentration, regardless of whether background is greater than or less than the numerical water quality limit, the soil constituent does not threaten water quality. No further action is required for that constituent in that lithology, provided that the concentration does not present a risk to human health.
4. When the background ground water concentration is less than the numerical water quality limit for a constituent, the assessment site soil leachate concentration is compared to the numerical water quality limit to determine the threat to beneficial uses, and is compared to the background ground water level to determine the threat of ground water degradation.
- a. If an assessment site soil leachate concentration is greater than the numerical water quality limit (and also background in this case), the constituent not only threatens to degrade ground water, but poses a threat to beneficial uses, as well. Then, the degree of attenuation that would be necessary to protect beneficial uses is determined by dividing the numerical water quality limit into the assessment site soil leachate concentration.
    - i. If the calculated degree of attenuation is available between the base of the contaminated soil and the highest level of ground water, the soil constituent does not threaten beneficial uses, but may threaten to degrade ground water. Further assessment is required for that constituent in that lithology per Section 4.b. below.
    - ii. If the calculated degree of attenuation is not available between the base of the contaminated soil and highest ground water, the soil constituent threatens beneficial uses (pollution) in addition to threatening ground water quality (degradation). Then, the constituent must be remediated to below the beneficial use protective level, and to the lowest level that is technologically and economically achievable.
    - iii. If the same contaminant is present both in ground water and in overlying soils, contaminant breakthrough has occurred and no attenuative capacity is available for that constituent within overlying soils.
  - b. If an assessment site soil leachate concentration is greater than background, the soil constituent may threaten to degrade ground water. Then, the degree of attenuation necessary to protect ground water quality is determined by dividing the background ground water concentration into the assessment site soil leachate concentration.
    - i. If the calculated degree of attenuation is available between the base of the contaminated soil and highest ground water, then the soil constituent does not threaten ground water quality. No further action is required for that constituent in that lithology, provided that the concentration does not present a risk to human health.

- ii. If the calculated degree of attenuation is not available between the base of the contaminated soil and highest ground water, then the soil constituent threatens ground water quality, and the soil must be remediated to the lowest level that is achievable, considering both technological and economic factors.
  - iii. If the same contaminant is present both ground water and in overlying soils, contaminant breakthrough has occurred and no attenuative capacity is available for that constituent within overlying soils.
5. When the background ground water concentration is greater than the numerical water quality limit for a constituent, the assessment site soil leachate concentration is only compared to the background ground water concentration to determine both the threat to beneficial uses and the threat of degradation, following the steps in Section 4.b. above.

To aid in understanding and applying this narrative discussion for determining background, and conducting a water quality site assessment for ground water and soils, the following attachments have been included:

Attachment A	(Narrative)	Environmental Leachate vs. WET Extract
Attachment B	(Flow Chart)	Water Quality Site Assessment: Ground Water
Attachment C	(Flow Chart)	Water Quality Site Assessment: Soil
Attachment D	(Narrative)	Water Quality Site Assessment Methodology
Attachment E	(Table)	Water Quality Site Assessment Table

# Environmental Leachates vs. Laboratory Extracts

Waste Extraction Test (WET) and Toxicity Characteristic Leaching Procedure (TCLP) extract concentrations are not intended to mimic constituent concentrations in landfill or environmental leachates. The WET was designed to measure the mass of constituents that could be mobilized from a given mass of waste if the waste were to be disposed of in an unlined municipal landfill -- a “reasonable worst-case” scenario. WET and TCLP extract concentrations are largely dependent on the waste-to-extraction solution ratio used in the extraction procedure. As stated in the 1984 Final Statement of Reasons (SOR) for the adoption of the California Code of Regulations (CCR), Title 22 hazardous waste identification regulations, including the WET:

“... it was assumed that under environmental leaching conditions the maximum concentration of extractable contaminant in the initial leachate in mg/l would reach, if not exceed, its concentration in mg/kg in the waste. This assumption is valid for the following reasons:

- “a. In a typical environmental leaching or extraction situation, the ratio of waste to aqueous extractant will be high. EPA has likened the situation to a drop of the leachate percolating through the mass of a landfill (EPA 1980g).
- “b. Under a range of conditions the mass of contaminant extracted from a waste in terms of mg/kg is largely independent of the waste-to-extract ratio. However, the concentration of the contaminant in the extractant in milligrams per liter varies directly with the ratio (Ham et al. 1980).”

In the *Designated Level Methodology*, as in the SOR for the hazardous waste identification regulations, the initial environmental leachate concentration is assumed to be numerically equal to the concentration in the waste prior to leaching. The SOR further states:

“The concentration of substances in a laboratory-derived leachate (i.e., extract) is an irrelevant factor, because these concentrations depend on the quantity of extractant, as well as other factors. Under nonequilibrium conditions, the concentration of an extracted substance in the extract will be approximately proportional to the waste-to-liquid ratio maintained during the test (i.e., the more extract solution used, the more dilute will be the extracted substance in the extract). When conducting an extraction in the laboratory, low waste-to-liquid ratios of 1:10 to 1:20 are required for ease in conducting the test (i.e., stirring, filtering, etc.). These low ratios of waste-to-extraction solution artificially lower the resulting concentrations of metals in the extract.

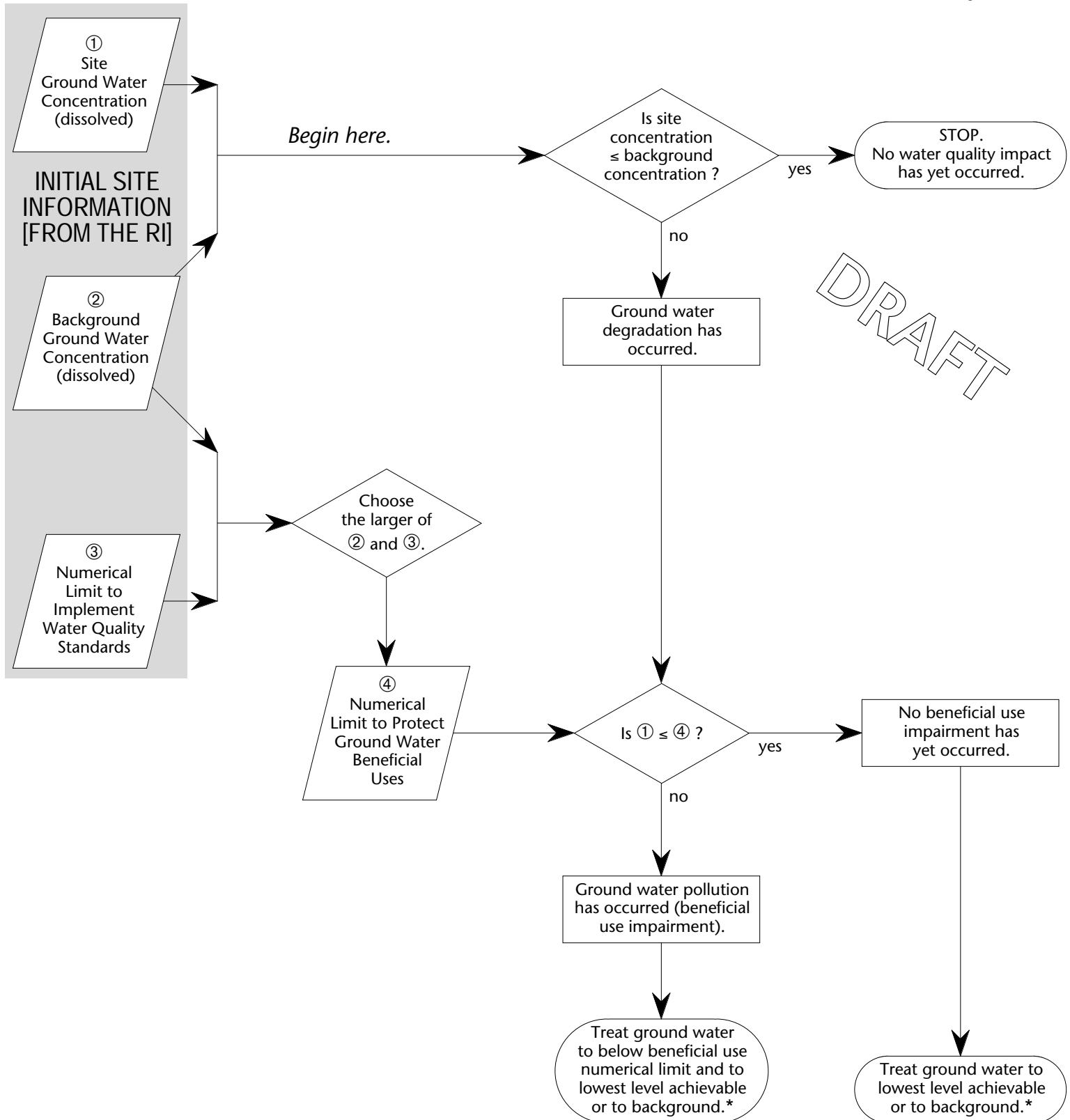
“In an actual landfill environment, the waste-to-liquid ratios will be very high as leachate percolates slowly through a deposit of waste. The situation cannot be duplicated in a laboratory batch extraction test. The concentrations seen in laboratory-derived extracts, using low waste-to-liquid ratios, will have no bearing on concentrations existing at any instance within the landfills.

“... Within the waste-to-liquid ratios normally used in laboratory extraction tests, researchers have demonstrated that the ratio has little effect on the quantity of metal extracted.”

# Water Quality Site Assessment: Ground Water

Perform the following for each constituent of concern.

JM 11/4/92



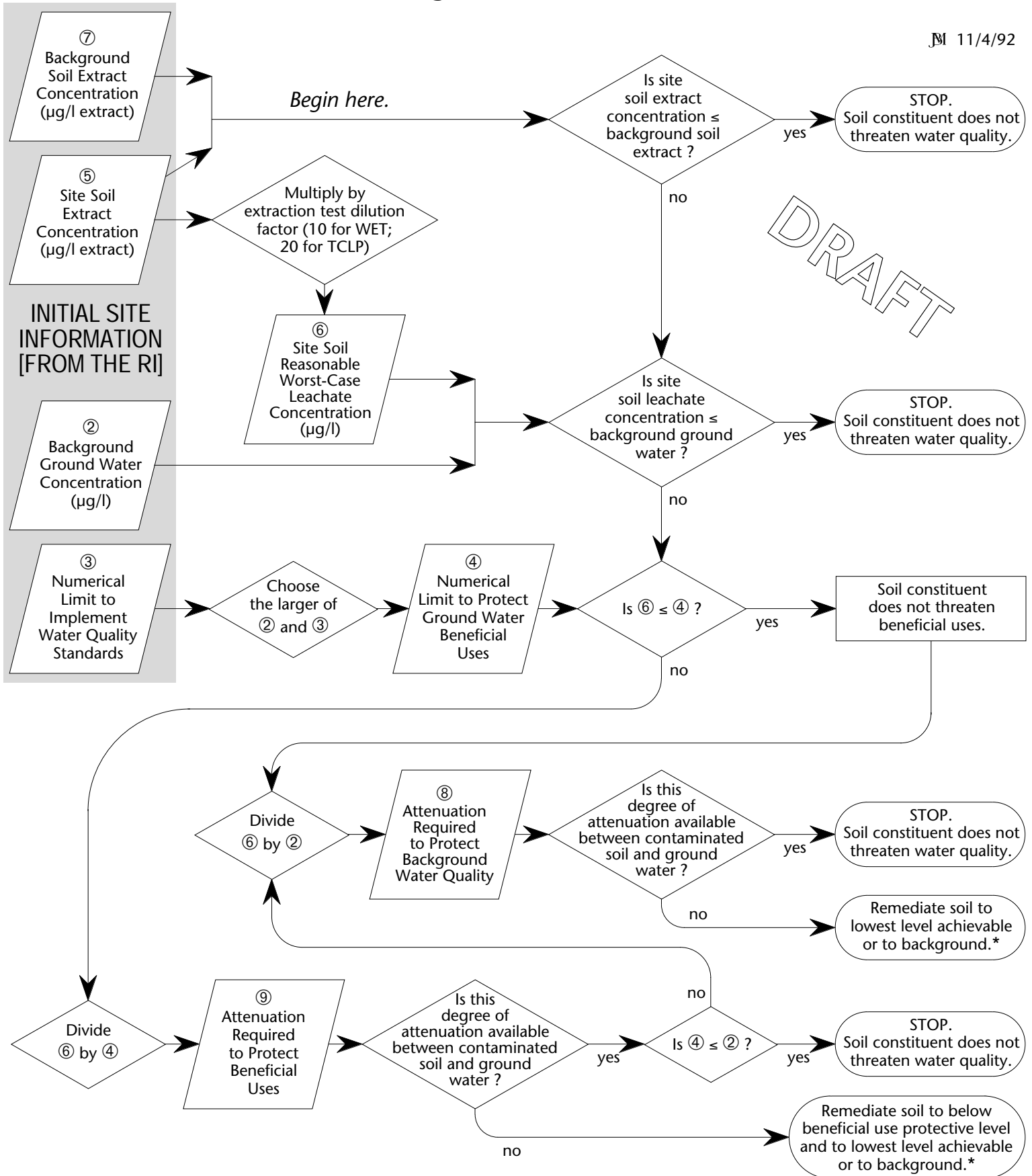
\* State Water Board Resolution Nos. 68-16 and 92-49 and 22 CCR §2550.4, require cleanup to background unless infeasible to do so. In addition, cleanup level must present no risk to human health or to the environment (per conventional risk assessment procedures).



# Water Quality Site Assessment: Soils

Perform the following for each constituent of concern.

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\* State Water Board Resolution Nos. 68-16 and 92-49 and 22 CCR §2550.4, require cleanup to background unless infeasible to do so. In addition, cleanup level must present no risk to human health or to the environment (per conventional risk assessment procedures).

# Water Quality Site Assessment Method

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## ***For each constituent:***

- ① = Site ground water concentrations (ug/l)
- ② = Background<sup>a</sup> ground water concentrations (ug/l)
- ③ = Numerical water quality limits protective of beneficial uses
- ④ = The higher of ② and ③ for each constituent<sup>b</sup>
- ⑤ = Contaminated soil WET extract concentrations (ug/l extract)
- ⑥ = Contaminated soil potential leachate concentrations (ug/l) = ⑤ x 10<sup>c</sup>
- ⑦ = Background<sup>a</sup> soil WET extract concentrations (ug/l extract)
- ⑧ = Attenuation<sup>d</sup> that would be required to protect background water quality = ⑥ ÷ ②
- ⑨ = Attenuation<sup>d</sup> that would be required to protect beneficial uses = ⑥ ÷ ④

## **Perform the following comparisons in order.**

### ***Ground Water:***

- If ① ≤ ②, then no water quality impact has yet occurred.
- If ② < ① < ④, then water quality has been impacted (degradation has occurred) but beneficial uses have not yet been affected.
- If ① ≥ ④, then beneficial uses have been affected (pollution has occurred).

### ***Soils:***

- If ⑥ ≤ ②, then contaminated soils pose no threat to water quality; STOP.
- If ⑤ ≤ ⑦, then contaminated soils pose no threat to water quality; STOP.
- If ⑤ > ⑦, then calculate ⑧ above. Is this degree of attenuation<sup>d</sup> available at the site? If not, contaminated soils threaten ground water quality (threat of degradation).
- If ⑥ ≤ ④, then contaminated soils pose no threat to beneficial uses; STOP.
- If ⑥ > ④, then calculate ⑨ above. Is this degree of attenuation<sup>d</sup> available at the site? If not, contaminated soils threaten beneficial uses of ground water (threat of pollution).

<sup>a</sup> Background = out of the influence of waste management activities (per Chapter 15, Article 5).

<sup>b</sup> Regional Board does not expect discharger to improve on background conditions (see Resolution 92-49).

<sup>c</sup> Dilution caused by the WET (50 grams soil in 500 milliliters of extract solution).

<sup>d</sup> Within clean soil between the base of contaminated soil and the highest elevation of ground water.

## WATER QUALITY SITE ASSESSMENT TABLE FOR \_\_\_\_\_

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